THE BABCOCK TEST

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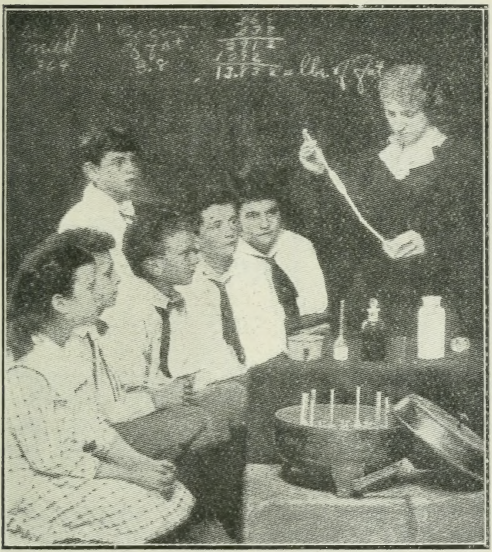

Testing the farmers' milk and teaching their children.

Reprinted, with adaptations, from "THE BABCOCK TEST, AND TESTING PROBLEMS," *by H. C. Troy, in* "*Cornell Reading Courses.*"

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THE BABCOCK TEST

H. C. Troy.

THE BABCOCK TEST AND TESTING PROBLEMS.

Previous to 1890 practically all milk was bought and sold by weight or measure regardless of its composition. In that year Dr. S. M. Babcock invented the milk-fat test that bears his name. By the application of this test it has become generally known that the percent-

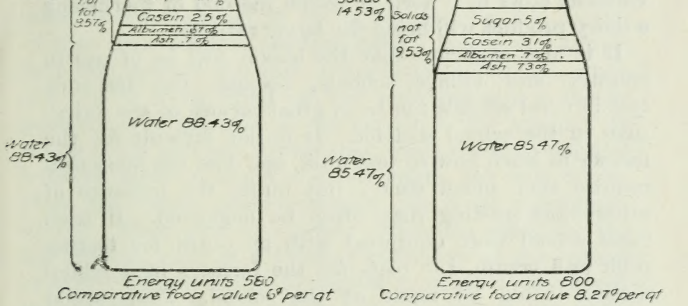

Fig. 99.—*Comparison of average composition and food value of milk containing 3 and 5 per cent. of fat.*

age of fat in milk from different herds often varies widely. This fact is important because fat is the most valuable milk constituent, and often forms the chief basis in fixing the price of milk. The farmer cannot now determine whether it will be more profitable to

sell his milk by the hundredweight or on the milk-fat basis, unless he first tests the milk.

It is also necessary for the farmer to know the amount of milk produced by a cow and the percentage of fat her milk contains when he fixes her market value or attempts to improve his herd by removing the poorer cows and by replacing them with better ones. The farmer cannot intelligently select young stock for building up his herd unless he has the milk and fat records back of the dams and sires to direct him.

In this lesson, an attempt is made to give directions that will assist dairymen in determining the percentage of fat in milk and cream, and by practical problems to point out how they may determine which are the valuable cows in a herd or which method of marketing a dairy product will bring the larger returns.

It is also expected that the lesson will be of use in country and village schools, because the Babcock test in rural schools can be of great service to the dairyman in the school district. It is not difficult for the farmer to learn how to test milk, nor does the operation require very much time; but under the pressure of other work testing may often be neglected. If each rural school were equipped with an outfit for testing milk and cream, the tests for the farmers in a school district could be made at the school. That would reduce the expenses very much because one set of testing apparatus would serve many dairymen. The teacher could instruct the older pupils to make the test and assist in the work. They would quickly learn the best method of performing each part of the operation and would gain confidence to continue the practice of testing their herds. The test can also be made the basis for problems in arithmetic that will quicken the pupils'

interest when the application is so readily seen. The pupils will find real pleasure in making the test, and they will become interested in a useful work when comparing the milk and fat records of different cows and herds, and the methods of feeding and breeding that produce the best results.

FAT VARIATIONS IN MILK.

There are several causes for the variations in the percentage of fat in pure milk. One of the most important is the breed of the cows. Next comes the individual of the breed. The percentage of fat in the milk of an individual in extreme cases may average either one per cent. above or one per cent. below the breed average. Also, the percentage of fat is affected by the length of time since the cow has freshened. It is a well-known fact that toward the end of the lactation period, when the cow is being dried off, the milk contains a higher percentage of fat than it did earlier in the season. It is also fairly well established that, when the time elapsing between milkings is not of equal length, the milk drawn after the longer period contains the lower percentage of fat. There are also minor influences affecting the fat content, such as a feverish condition of the animal or over-excitement, due to dogging or other ill treatment that might cause the cow to hold up part of her milk, thus giving a larger proportion of the milk that is first let down, which is not so rich in fat as the strippings. It has become a well-established fact that the character of the food of an animal has very little effect on the percentage of fat in the milk, although it has a marked effect on the amount of milk and fat produced.

Fat exists in milk in the form of very small globules. With the aid of a high-power microscope they may

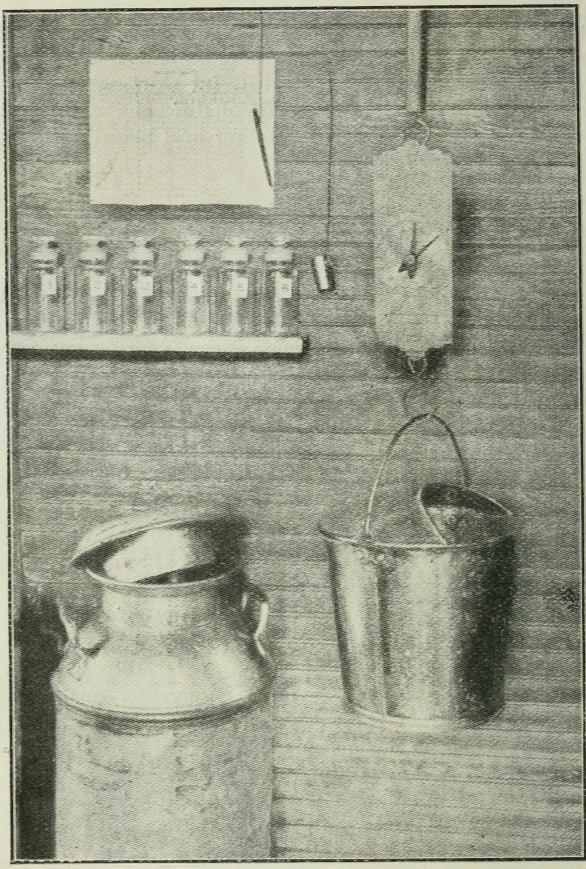

FIG. 100.—*Milk sampling outfit.*

be seen floating in the liquid. Since the fat globules are lighter than the other milk constituents, most of them rise to the surface under the influence of the force of gravity. There, mixed with other milk substance, these globules form a layer of cream.

When sulphuric acid of proper strength and temperature is added to milk, as in the Babcock fat test, the casein, the milk sugar, and the albumen are decomposed, and the sticky quality of the milk is destroyed. The acid does not, however, decompose the fat, but leaves it free to come to the surface of the mixture under the influence of centrifugal force generated in the testing machine.

EQUIPMENT.

The testing equipment that a dairyman should purchase may vary according to different circumstances. If the farmers in a neighbourhood arrange to have their milk tested at a central point, such as a district school, then each would need to purchase only the sampling outfit, which would cost between three and four dollars. If they tested their milk at their homes, in addition to the sampling outfit each would need the milk-testing outfit and, for the accurate testing of cream, the additional cream-testing apparatus.

MILK-SAMPLING OUTFIT.

Spring scales	$3.00
Record sheet	.05
Sampling dipper	.15
Six sample jars	.60
	$3.80

MILK-TESTING OUTFIT.

2 pipettes with capacity of 17.6 c.c. . .	$0.40
12 Babcock milk test bottles	1.50
2 skimmed milk test bottles	1.00
2 acid measures with capacity of 17.5 c.c.	.25
1 twelve-bottle tester	12.00
1 tin cup with spout	.25
1 gallon of sulphuric acid	.75
	$16.15

ADDITIONAL APPARATUS FOR TESTING CREAM.

4 cream test bottles	$1.00
1 cream scales	8.00
1 tin pail	.15
1 thermometer	.50
1 pint of meniscus remover (glymol)	.25
1 dropping pipette	.10
	$10.00
Total	$29.95

When ordering Babcock milk or cream test bottles or 17.6 cubic centimetre milk pipettes, the buyer should specify "Standard Babcock Glassware" that has been tested for accuracy.

MILK SAMPLING OUTFIT.

In the sampling outfit, bottles holding between four to eight ounces, or from one-fourth to one-half pint, could be substituted for the sample jars. The wide neck of the latter, however, permits the milk to be added quickly without danger of loss and also enables the operator to observe the condition of the sample and to clean the jar more readily. The jar should be labelled with the name or number of the cow producing the milk sample. The sampling dipper should hold an ounce and should have a wire handle about a foot long. A spring scales, permanently suspended near the location of the receiving cans, affords the simplest method of weighing the milk. A convenient arrangement of the sampling apparatus is shown in Fig. 100.

If it is impossible to afford a spring scales, the weight of the milk may be calculated. To do this, first accurately measure the milk, then multiply the number of quarts by 2.15, as one quart of average milk weighs about 2.15 pounds. Thus if a cow yields 7.25 quarts at a milking, the weight of the milk would be approximately 15.58 pounds.

$$7.25 \times 2.15 = 15.58 \times$$

MILK-TESTING OUTFIT.

The number of test bottles that should be ordered with the testing outfit depends on the amount of testing to be done. Usually two test bottles are allowed for each cow in the herd. Two each of pipettes, acid measures, and acid bottles would be sufficient. Then if one were broken, another would be ready for use. Where hand power is used, the covered form of twelve-bottle hand tester is safer than the four-bottle machine. It also may be kept at a proper temperature with less

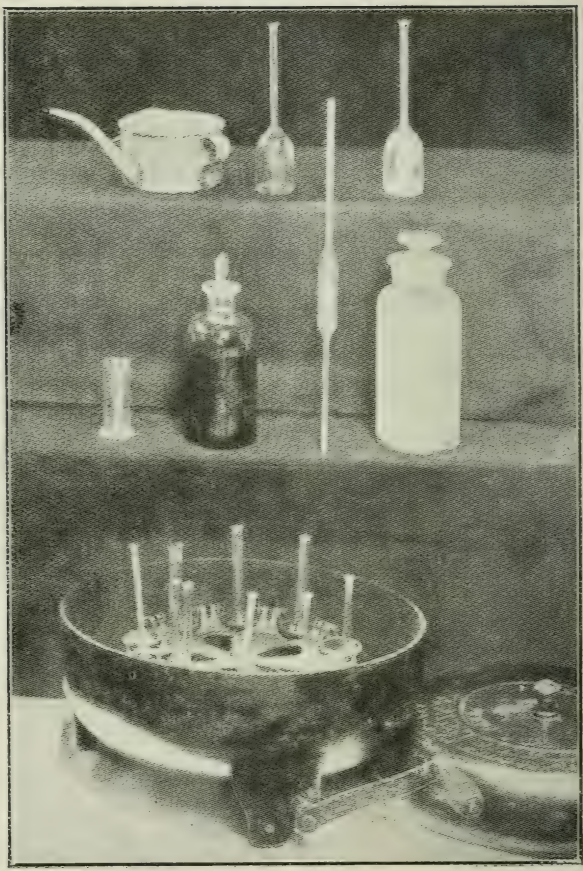

FIG. 101.—*Milk-testing outfit.*

difficulty than the smaller machine. The four-bottle tester might serve where only one or two cows are to be tested.

The sulphuric acid may be bought at almost any drug store. The buyer should state that the acid is to be used in the Babcock test and that it should be of such concentration that it will have a specific gravity between 1.82 and 1.83. The acid should be kept in glass-stoppered jugs or bottles; otherwise it will absorb moisture from the air and become too weak to dissolve the milk solids and free the fat. Acid that is too strong might burn the fat. The acid is a strong poison, and if it happens to come in contact with the flesh or the clothing, should be removed at once by washing with large quantities of cold water. Bicarbonate of soda (common baking soda), ammonia, or a similar alkaline substance should be applied to remove any acid not washed away.

CREAM-TESTING APPARATUS.

There are several forms and sizes of cream test bottles. The six-inch nine-gram bottles are preferable especially for use in hand testers. This form of bottle has a scale graduated to read from 0 to 50 per cent., the smallest scale divisions equalling 0.5 of 1 per cent.

The balance for weighing cream test samples should be sensitive to .1 of a gram. A form of balance should be bought that may also be used for general weighing purposes, especially if it is for use in a school. There it may be used in many instructive experiments that will interest the pupils and form the basis of many problems in arithmetic. A good form of druggist's dispensing balance with a set of weights in grams would serve well. It would be the least expensive and most durable.

An ordinary four-quart pail would serve as a vat in

which to bring the fat in the cream test bottle to the proper temperature before adding the meniscus remover and reading the test. The vat should be of such depth that when it is nearly full of water and the cream test bottles are placed upright in it, the upper surface of the water and of the fat columns will be on about the same level.

The thermometer should be of a form that registers each temperature degree between the freezing and boiling points of water. That would permit of its use for a variety of purposes.

The meniscus remover is made from a purified mineral oil that has been coloured red with alkanet root. It is sometimes called glymol. When placed on the top of a fat column in a cream test bottle, it flattens the curved surface, which is known as the meniscus.

RURAL SCHOOL TESTING EQUIPMENT.

A complete testing equipment for a rural school would include all the apparatus listed. The sampling apparatus would be useful in showing dairymen what they should have. Or the school might first obtain the milk-testing outfit if it could not afford the complete list, and the other apparatus could be added as the work progressed. The covered twelve bottle tester should always be used where children are present, in preference to the open form of smaller machine, because there would be much less danger of accident.

TAKING TEST SAMPLES.

The milk from each cow in a herd should be weighed and tested at regular intervals. A very good practice is to weigh and test the milk on the first, the tenth, and twentieth of each month. Since there is likely to be a little difference in the percentage of fat in the night's

and morning's milk, it is preferable each time to weigh and sample two successive milkings.

FIG. 102.—*Correct position of the pipette and test bottle while transferring the milk.*

At milking time a pail of known weight may be hung on the scales and the milk from a cow poured into it and weighed. When several pails are used, it is convenient to make them all of equal weight by attaching solder to the bottoms of the lighter ones. Then when a cow is milked, the pail may be hung on the scales. The weight of each cow's milk should be set down after the name or number of the cow on the record sheet. The milk should then be mixed by pouring it from one pail to another or by thorough stirring. By use of the sampling dipper two ounces of the milk should immediately be placed in the sample jar. The jar should be stoppered and kept in a cool place until more milk is added or until the milk is

tested. It would be well to first weight and sample the night's milk; then a sample from the morning's milk taken in like manner could be added to it and the mixture tested. Or each sample could be held and tested separately.

TESTING THE MILK.

Mix the milk by pouring, allowing it to flow down the side of the vessels to avoid incorporating air bubbles. Vigorous shaking should be avoided. See that all cream is removed from the sides of the sample bottle and that it is evenly distributed throughout the milk. Then, holding the pipette between the thumb and the second finger of the right hand, place its tip well under the surface and draw in the milk by suction with the lips on the upper end until it is filled well above the graduation. Quickly place the fleshy pad of the forefinger over the opening and at right angles to the pipette. By rolling the pipette a little between the thumb and the second finger sufficient air will enter to allow the milk to run out slowly until the upper surface is exactly level with the graduation. The pipette should be held perpendicular at this time with the graduation on a level with the eye.

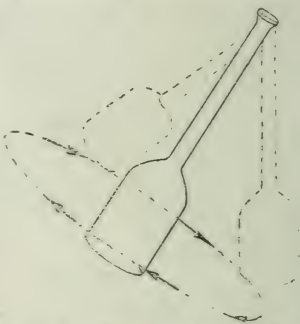

FIG. 103.—*Diagram showing the motion and position of a test bottle while mixing the milk and the acid.*

Hold the milk test bottle in a slanting position and

place the tip of the pipette into it about one-third of an inch and at a slight angle (fig. 102). Allow the milk to flow slowly down the side of the bottle neck, making certain that none is blown out by the escaping air. Blow the drop that remains at the tip of the pipette into the test bottle. Measure out another test sample in the same manner, as the test must be made in duplicate.

ADDING THE ACID.

Fill the measure to the mark with acid, and then rotate the test bottle slowly while adding the acid so that it will rinse down any milk remaining in the neck. Immediately mix the acid and the milk thoroughly by whirling the body of the bottle in a circle five or six inches in diameter (fig. 103), using care to keep the mixture out of the neck of the bottle. Shake the mixture vigorously for about one minute after all curd has disappeared, and shake it again just before centrifuging to insure complete solution. Avoid pointing the neck of the bottle toward any person during the mixing operation, and so prevent the possibility of having acid thrown into the eyes or on the clothing. The acid unites with all of the milk substances except the fat, thus generating much heat. The temperature of the mixture usually rises to 225° F.

CENTRIFUGING THE BOTTLES.

First heat the centrifuge either by placing it on a stove or by adding a few quarts of boiling water. A corked opening in the bottom provides a means of removing the water.

The disc of the machine must be balanced by placing test bottles in exactly opposite pockets. Cover the machine before turning the handle. About eighty revolutions of the handle per minute usually generate one

thousand revolutions, the required speed of the disc. After whirling the bottles for five minutes, stop, and, without removing the bottles from the pockets, fill them nearly to the base of the neck with water that is nearly boiling hot. The pipette or a tin cup with a slender spout may be used for this purpose (fig. 104). Whirl the bottles again for two minutes in order to wash any sediment from the fat. Again add hot water to the test bottles until the top of the fat column is a little below the highest graduations on the scale. Whirl the bottles for one minute, and take the readings immediately. If the tests are not read immediately, they should be held at a temperature between 130° and 140° F. either by keeping the centrifuge hot and covered or by placing the test bottles in water at that temperature and deep enough to surround the fat columns.

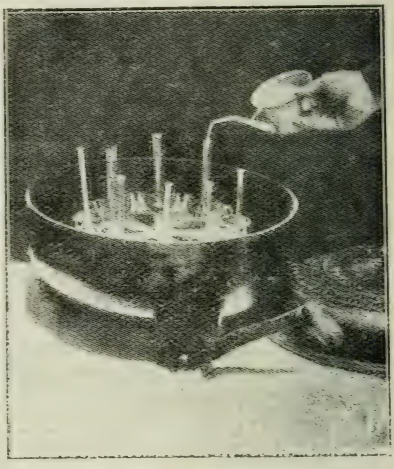

FIG. 104.—*Pouring the hot water into the bottles.*

READING THE PERCENTAGE OF FAT.

Subtract the reading on the scale at the base of the fat column from the reading at the highest point at the

top of the fat column. The difference is the percentage of fat in the milk. Thus, if the scale at the base of the column reads 1.7 and at the top it reads 5.8, then $5.8 - 1.7 = 4.1$, the percentage of fat in the milk. The curved surface called the meniscus, which always exists at the top of the fat column, must be included in the reading, as it is just large enough to make up for a small amount of fat remaining down in the body of the bottle. The limit of error for the test is usually less than .2 of 1 per cent. When such a difference occurs in a duplicate test, the average of the duplicate readings should be taken.

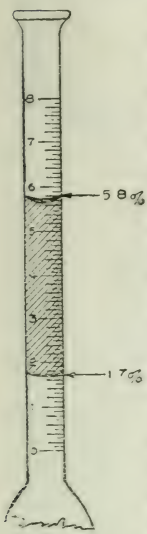

FIG. 105—*Method of reading the percentage of fat in milk.*

The arrows indicate the points on the scale at the ends of the fat column at which the readings should be taken.

SAMPLING CREAM.

Cream differs from milk by containing a higher percentage of fat. Cream containing 30 per cent. of fat would contain 70 per cent. of skimmed milk substance, or milk serum. Before sampling, the fat should be evenly distributed by thorough mixing or pouring. If the cream is old or lumpy or some has dried on the container, it should be warmed to about 95° F. and the lumps should be passed through a strainer before mixing. Then about two ounces should be placed in the sample bottle.

TESTING THE CREAM.

The test sample must be weighed instead of measured because :

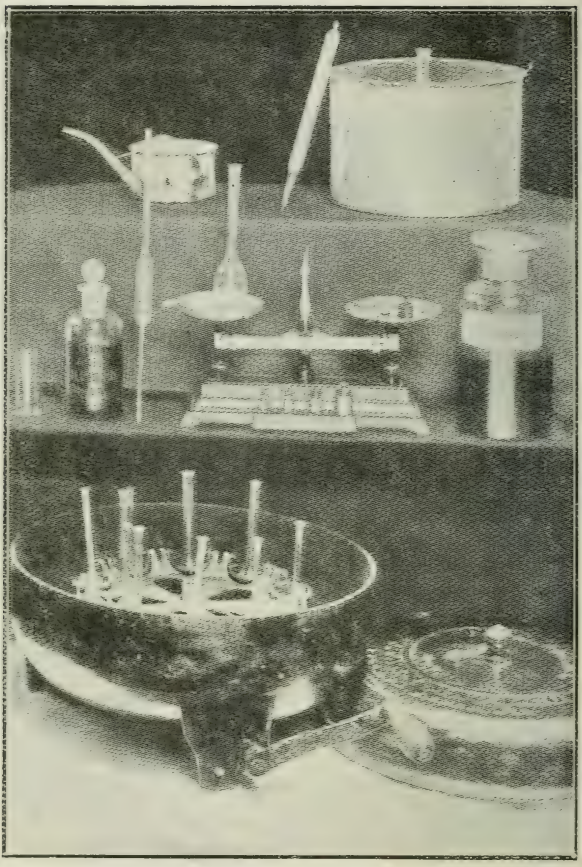

FIG. 106.—*Cream-testing outfit.*

1. The percentage of fat and the specific gravity of cream vary widely, and the weight of a definite volume would vary accordingly.

2. Cream may contain bubbles of air or of carbon dioxide.

3. Cream varies so widely in viscosity (sticky quality) that the amount delivered or the amount remaining in the pipette would be unknown.

In testing cream 9 grams is used. Balance the bottle on the scales, and place a 9-gram weight on the opposite side. Mix the sample thoroughly, and by means of a pipette transfer cream to the test bottle until the scales exactly balance. Next add about 9 cubic centimetres of water to the test bottle. (This water may be measured with sufficient accuracy in the acid measure by filling it a little over halfway to the mark.) Add about 15 cubic centimetres of the acid to the test bottle, and mix the contents thoroughly. The cream and acid mixture should not turn black but should remain coffee colour. About 15 cubic centimetres of acid gives the proper concentration to dissolve the solids not fat, since the fat forms such a large part of the mixture and does not go into solution. Centrifuge the bottles, and add the water exactly as in testing whole milk.

TEMPERING THE FAT AND READING THE PERCENTAGE.

When the last whirling is completed, transfer the test bottles to the tempering vat containing water held at a temperature of 140° F. The water should be tempered in advance, and it should be deep enough to surround the necks of the bottles to the top of the fat columns. After four minutes take the bottles from the water, and add the meniscus remover at once by placing the tip of a dropping pipette containing some

of the substance against the inside of the bottle's neck, which is held in a slightly slanting position (fig. 107). The red liquid is allowed to run slowly down the inside of the neck and spread over the fat to a depth of about one-fourth of an inch. It should not mix with the fat.

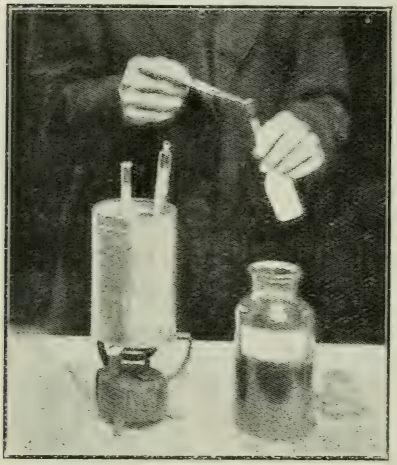

FIG. 107.— *Adding the meniscus remover to the cream test.*

Read the test immediately by subtracting the number on the scale at the bottom of the fat column from the number on the scale at the line of division between the fat and the meniscus remover. Thus if the bottom line of the fat column reads 12 and the line between the meniscus remover and the fat at the top reads 39, the percentage of fat would be 27.

In testing milk the meniscus should be included in the reading as it is just sufficient to make up for the fat that is not brought up by the test. But the volume of the meniscus on the cream test is much larger than the one on the milk test, while the amount of impurities in the larger volume of fat in the cream test is about suffi-

cient to make up for any fat remaining down in the bottle. Therefore the meniscus on the cream test should be removed before reading the percentage of fat.

FIG. 108. — *Method of reading the percentage of fat in cream.*

The arrows indicate the points on the scale at the ends of the fat column at which the readings should be taken

WASHING BABCOCK GLASSWARE.

Wash the glassware thoroughly between each test. Any fat remaining in the test bottles would increase the following test. First empty the contents of the test bottles on an ash heap or some place where the mixture will not come in contact with the food or the feet of animals. Do not empty the mixture into ordinary sinks or drains because the acid solution will destroy the sink and piping. Then rinse out the bottles with hot water. Add a strong hot solution of a good washing powder until the bottles are half full. Shake them vigorously while emptying them, and pass a small brush through the necks; then rinse them again using plenty of hot water. The bottles will then be ready to use in another test

The pipette should be rinsed out with water immediately after measuring out the samples, for if the milk is allowed to dry it will be difficult to clean the instrument. It should also be washed with the hot soap solution when the bottles are being washed, and well rinsed afterwards.

A simple tray for holding test bottles (fig. 109) while carrying or washing them is made by boring twelve or fourteen holes, to fit the bottoms of the bottles, nearly through a piece of plank 12 inches long, 6 inches wide, and 1.5 inches thick. A cover half an inch thick is made with corresponding holes. The holes in the cover should be large enough to permit the necks of the bottles to pass through, but not the bodies.

When several bottles are to be emptied and washed, they may be placed in the block and the cover placed down over them. By holding the block and cover together at each end, several bottles may be shaken or emptied as quickly as one.

TESTING SKIMMED MILK AND BUTTERMILK.

The skimmed milk test bottle (fig. 110) is also used in testing buttermilk, and the operation is the same for each substance. The graduated neck of the skimmed milk test bottle has a very small bore in order to measure the fat accurately. A second neck with larger bore is attached to provide a convenient means of filling the bottle. The smallest divisions on the scale usually indicate .01 of 1 per cent., but on some bottles they indicate .05 of 1 per cent.

The same care is necessary in mixing and sampling skimmed milk and buttermilk that is required for whole milk, and the same pipette is used in measuring out the sample. The skimmed milk is added to the test bottle through the larger neck. Since a little more acid is necessary to thoroughly free the fat in skimmde milk, the measure should be filled to about a quarter of an inch above the mark. First add about one-half of the acid, and shake the mixture thoroughly; then add the remainder, and again shake it vigorously for about a

minute. Avoid throwing undissolved casein into the small neck while mixing the milk with the acid. The bottles are then centrifuged and filled in the same manner as in testing whole milk, except that the first whirling should be continued for ten minutes, instead of five, in order to bring up all the smaller fat globules. The percentage of fat is read immediately on completing the final whirling.

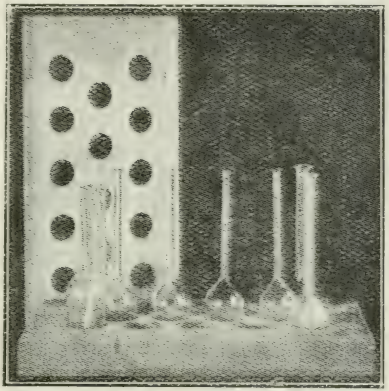

FIG. 109.—*Tray and cover for holding test bottles.*

SPECIAL EXPLANATIONS.

While one may be able to make the Babcock test successfully without knowing all the basic facts on which it depends, a knowledge of them is often of advantage. This applies especially when difficulties are met in getting correct tests or when teachers are explaining the test and answering questions. Therefore a few of the fundamental principles are explained here.

SPECIFIC GRAVITY.

When equal volumes of milk and water are weighed it will be found that the milk is heavier. A vessel that holds 1,000 grams of water will hold 1,032 grams

of average milk : or for each gram of water there would be 1.032 grams of milk. 1,032÷1,000 = 1.032. Therefore 1.032 equals the specific gravity of milk, since it is the existing ratio between the weights of equal volumes of milk and the standard substance water. One cubic centimetre of water at the proper temperature (4° C., or 15.55° F.) weighs one gram.

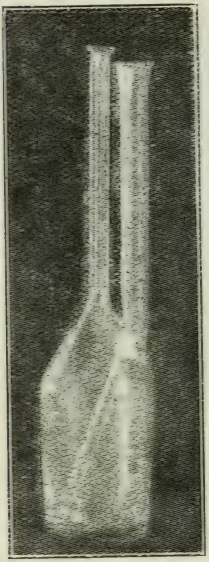

FIG. 110.—*Skimmed milk test bottle.*

THE PIPETTE.

The Babcock pipette used in measuring milk test samples delivers 18 grams of milk. 18÷1.032 (the specific gravity of milk) = 17.44, the cubic centimetres of milk delivered into the test bottle. The pipette is made to hold 17.6 cubic centimetres because it has been found by experiment that the difference between 17.6 cubic centimetres and 17.44 cubic centimetres, or .16 cubic centimetre, remains in the pipette.

THE MILK TEST BOTTLE.

When the Babcock test was first invented, the scale on the neck of each test bottle was graduated to read from 0 to 10 per cent. The smallest graduations indicated .2 of 1 per cent. In recent years preference has been given to a test bottle that has a scale in which the smallest divisions indicate .1 of 1 per cent. The scale on this bottle reads from

0 to 8 per cent. Both forms of bottles are in use at the present time.

The graduated portion of the neck of the 10-per-cent. bottle holds 2 cubic centimetres. One cubic centimetre of butterfat at a temperature of 140° F. weighs .9 of a gram. Therefore if the graduated portion of the neck of the milk test bottle were full of fat, it would contain 1.8 grams. That would be 10 per cent. of 18 grams. $1.8 \div 18 = .10$. $.1 \times 100 = 10$ per cent. Eighteen grams is the weight of the milk placed in the test bottle. When 2 cubic centimetres, the volume in the neck, is divided into ten equal parts, one part equals one per cent.

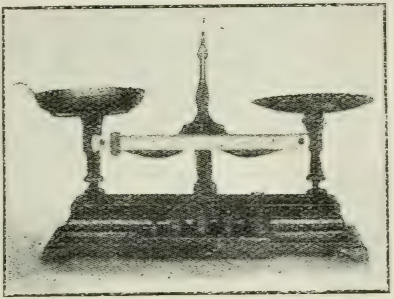

FIG. 111.— *A convenient form of scales for weighing cream samples. Especially good for use in schools.*

APPEARANCE OF A COMPLETED TEST.

In a completed test the fat should be straw yellow in colour; the ends of the fat column should be clearly and sharply defined; the fat should be free from specks and sediment; the water in the neck just below the fat should be clear; and the fat should be in the graduated part of the neck. Some of the defects and remedies are explained in the following paragraphs.

If the fat column is too dark in colour, the acid may

have been too strong, or too much may have been used, or the temperature of the milk and the acid may have been too high just before mixing. Mixing too slowly might also permit charring of part of the fat. The charred or darkened condition of the fat may be corrected to some extent by using less acid, by cooling both milk and acid below 60° F. just before mixing, and by rapid, vigorous mixing continued for about a minute after all casein has been dissolved.

If the fat column is too light in colour, the acid was either too weak or too cold. This condition may be corrected to some extent in succeeding tests by using more acid and by having the milk and the acid at a little higher temperature when brought together.

If the acid is not of the correct strength (specific gravity 1.82 to 1.83), it will be difficult to get a correct test, but the trouble may be partially overcome by using more acid when it is weak and less when it is too strong.

HERD TESTING PROBLEMS.

The prices used in these problems are simply for the purpose of illustration. As the price of milk changes, regular market values may be substituted for the prices here given.

I.

A farmer had four cows : Bell, Spot, Fawn and Dot. The milk produced by each cow in two successive milkings was weighed, sampled, and tested three times during the month of April. The pounds of milk, the percentages of fat, and the dates the samples were taken, are recorded in Table 1 as follows :—

TABLE 1.

April..	1	2		10	11		20	21	
	Pounds of milk.		Percentage of fat.	Pounds of milk.		Percentage of fat.	Pounds of milk.		Percentage of fat.
	P.M.	A.M.		P.M.	A.M.		P.M.	A.M.	
Bell...	11.0	9.0	4.1	12.0	9.8	4.2	11.8	11.0	4.0
Spot...	16.0	15.0	3.2	18.0	15.0	3.1	17.5	16.0	3.1
Fawn..	9.0	10.5	3.7	10.0	11.0	3.7	11.4	10.0	3.6
Dot...	18.0	17.0	4.4	18.5	17.0	4.5	19.0	17.5	4.3

Problems.

1. Find the average number of pounds of milk and of fat that each cow produced per day, and the total number of pounds of milk and of fat produced by each cow for the month.

Solution of the problem for the cow named Bell—

	Pounds of milk.		Pounds of fat.
11.0 + 9.0	= 20.0 × .041	=	.820
12.0 + 9.8	= 21.8 × .042	=	.915
11.8 + 11.0	= 22.8 × .040	=	.912
	3) 64.6		3) 2.647
Average per day	= 21.53		.8823
30 days in April	30		30
Total for month	= 645.90		26.4690

The cow produced on the average 21.53 pounds of milk and .8823 pounds of fat per day, and during the month

she produced 645.9 pounds of milk containing 26.469 pounds of fat.

2. Compute the monthly income from each cow valuing the milk at $1.50 per hundred pounds.

3. Assuming that each cow gave as much milk as the best one, how much more money would the farmer have received during the month ?

II.

A herd of cows produced on an average 350 pounds of 3.8 per cent. milk per day during the month of June. The milk could be sold for $1.30 per hundred pounds, or it could be separated and the fat in the cream sold for 32 cents a pound. Assume that if the milk were separated there would be 9,520 pounds of skimmed milk containing 7 pounds of fat and that the skimmed milk would be worth 30 cents per 100 pounds when fed to farm animals.

Problems.

1. Which method of sale would bring the larger returns, and how much difference would there be ?

2. What percentage of fat would the cream contain ?

3. What percentage of fat would the skimmed milk contain ?

Solutions.

1. $350 \times 30 = 10{,}500$, number of pounds of milk for the month.

   $105 \times \$1.30$ per hundred pounds $= \$136.50$, returns when sold as whole milk.

10,500 × .038 = 399, number of pounds of fat in the milk.

399 — 7 = 392, number of pounds of fat in the cream.

392 × $.32 = $125.44, value of fat in the cream.

95.20 × $.30 per hundred pounds = $28.56, value of the skimmed milk.

$125.44 + $28.56 = $154.00, returns when the milk is separated.

$154.00 — $136.50 = $17.50

Therefore larger returns are obtained by separating the milk, and the difference is $17.50. Answer.

2. 10,500 — 9,520 = 980, number of pounds of cream.

10,500 × .038 = 399, number of pounds of fat in the milk.

399 — 7 = 392, number of pounds of fat in the cream.

392 ÷ 980 = .40 × 100 = 40.0 per cent. of fat in the cream. Answer.

3. 7 — 9,520 = .00073 × 100 = .073, per cent. of fat in the skimmed milk. Answer.

III.

The first year that a farmer kept an exact record of his herd of eight cows, he obtained the results given in table 2.

TABLE 2.

Number of cow.	Pounds of milk per year.	Average percentage of fat.	Cost of feed per year.
1	6,520	4.1	$51.00
2	5,740	4.3	51.28
3	5,590	3.9	49.50
4	4,900	4.6	45.70
5	4,625	3.7	43.90
6	4,150	4.0	43.50
7	3,960	3.8	42.80
8	3,425	3.8	42.20

Three years later, after improving his herd by testing, disposing of the poorer animals, selecting better ones, and practising better feeding methods, the farmer had eight cows that gave the following results (table 3).

TABLE 3.

Number of cow.	Pounds of milk per year.	Average percentage of fat.	Cost of feed per year.
1	11,862	3.9	$73.60
2	10,143	3.7	70.24
3	8,027	4.1	62.50
4	7,240	3.9	58.45
5	6,354	4.3	56.42
6	6,215	4.0	54.27
7	5,784	4.2	54.00
8	4,966	4.4	51.60

Problems based on the data in tables 2 and 3.

1. Compute the number of pounds of fat produced by each cow in (a) table 2, (b) table 3.

2. Find the average number of pounds of milk and of fat for the cows (a) in table 2, (b) in table 3.

3. What would be the value of the milk at $1.30 per hundred pounds for each cow in (a) table 2, (b) table 3 ?

4. Find for each cow in (a) table 2, (b) table 3, the difference between the cost of the feed and the income when the milk is sold at $1.30 per hundred pounds.

5. Find the value of the milk from each cow in (a) table 2, (b) table 3, computed on a basis of 32 cents a pound for the fat.

6. Find the value of the milk for each cow in (a) table 2, (b) table 3, allowing 30 cents a pound for the fat and 20 cents for the skimmed milk from each 100 pounds of whole milk.

7. Find for each cow in (a) table 2, (b) table 3, the difference between the cost of the feed and the income when the milk is sold on a basis of 32 cents a pound for the fat.

8. Find for each cow in (a) table 2, (b) table 3, the difference between the cost of the feed and the value of the milk, allowing 30 cents a pound for the fat and 20 cents for the skimmed milk from each 100 pounds of whole milk.

9. After deducting the cost of each cow's feed, how many cows like No. 7 in table 2 would it take to give the same income as that from (a) cow No. 1, table 2, (b) cow No. 1, table 3 ?

10. Compute the total value of the milk in table 2

at $1.30 per 100 pounds, and find how much milk there would have been, and how much it would have brought, if each cow had given as much milk as cow No. 1.

11. Compute the total value of the milk in table 3 at $1.30 per 100 pounds, and find how much more it would have brought if each cow had given as much milk as No. 1.

12. When milk is valued at $1.30 per 100 pounds, how much more would the owner of the cows in table 2 have received if each cow had given as much milk as cow No. 1 in table 3 ?

QUESTIONS AND ANSWERS.

These questions and answers were suggested by many inquiries received from dairymen.

1. What are the principal substances and the percentage of each in average milk ?

Answer.—Water, 87.37 per cent.; fat, 3.8 per cent.; casein, 2.6 per cent.; sugar, 4.8 per cent.; albumen, .71 per cent.; ash, .72 per cent.

2. What substances make up the milk solids ?

Answer.—All the constituents, except the water.

3. What percentage of solids is found in milk of average composition ?

Answer.—About 12.63 per cent.

4. How are the solids of milk sometimes classified for the purpose of comparison ?

Answer.—They are classified as fat and solids not fat.

5. What is the average percentage of solids not fat in milk ?

Answer.—About 8.83 per cent.

6. Which constituent of milk is the most variable in amount ?

Answer.—The fat.

7. Between what limits is the percentage of fat usually found ?

Answer.—Between 3 per cent. and 6 per cent.

8. What is meant when it is said that average milk contains 3.8 per cent. of fat ?

Answer.—This means that 100 pounds of milk of average composition contains 3.8 pounds of milk-fat.

9. In what condition does the fat in milk exist ?

Answer.—It is present in the form of very minute round particles called globules.

10. What is another property that distinguishes the fat from the other milk substances ?

Answer.—It is lighter in weight than the other milk substances.

11. How does the dairyman make use of these properties of the fat ?

Answer.—The lighter fat globules come to the top of the *milk serum* (skimmed milk) when he sets the milk, and he skims them off as cream with some of the serum ; or he passes the milk through a separator, and draws the cream off from the centre of the revolving bowl, while most of the heavier milk serum is thrown to the outside of the bowl and is drawn off through a separator spout.

12. Are milk serum and skimmed milk the same substance ?

Answer.—Yes.

13. How does the serum after separation differ from the cream ?

Answer.—The serum contains only traces of fat, while the cream is made up of both milk serum and fat.

14. Does the serum of cream differ from the serum forming skimmed milk ?

Answer.—The serum in each substance is the same.

15. What is meant when dairymen speak of 30 per cent. cream ?

Answer.—They mean that 100 pounds of the cream contains 30 pounds of fat and 70 pounds of the serum.

16. What is the legal requirement for milk in New York State ?

Answer.—Milk offered for sale in New York State must be clean and pure, and drawn from healthy cows. Nothing may be added to it and nothing taken from it, and it must contain at least 3 per cent. of fat and 11.5 per cent. of solids.

17. Does the 11.5 per cent. of solids include the fat ?

Answer.—Yes.

18. Give the legal requirement for cream in New York State.

Answer.—Cream must be made from clean pure milk, and contain not less than 18 per cent. of fat.

19. How does the skimmed milk obtained by setting the milk differ from that obtained by passing the milk through a good separator ?

Answer.—The skimmed milk from the separator contains less fat.

20. How much difference might one expect to find in the skimmed milk obtained by these two methods ?

Answer.—The skimmed milk from the separator should contain less than .1 of 1 per cent. of fat, while the other would probably contain between .25 and .5 of 1 per cent. of fat.

21. What is buttermilk ?

Answer.—Buttermilk is the substance found in the churn with the butter when the process of churning cream is completed.

22. Which substance in cream forms the butter and which the buttermilk ?

Answer.—The fat globules in the cream unite during the churning process to form the butter, while the serum of the cream remains as buttermilk.

23. Should not buttermilk, therefore, be very much like skimmed milk, since both are the same as milk serum ?

Answer.—Buttermilk is the same as sour skimmed milk, and contains about the same percentage of fat as skimmed milk from the setting process, except that the lumps of casein in the buttermilk have been broken into small particles during churning.

24. Why does milk turn sour and the casein coagulate ?

Answer.—Little plants, called bacteria, change the milk sugar into a substance known as lactic acid. The acid gives milk a sour taste and brings about the coagulation of the casein.

25. How do the bacteria usually enter the milk ?

Answer.—The bacteria fall in from the air on particles of dust or dirt, or they may be on the milk pails or other utensils.

26. What can a milk producer do to keep the bacteria out, and to prevent the milk from souring ?

Answer.—Keep the stable and the cattle clean.

Wipe off the cow's udder and surrounding parts with a damp cloth immediately before milking.

Use milk utensils that have been thoroughly cleaned and then sterilized with boiling water, or live steam for 30 minutes.

Wash the hands just before milking.

Use small-top milking pails.

Milk with dry hands.

Cool the milk to a temperature below 50° F. and keep it cold.

QUESTIONS.

1. Why should the farmer use some such test as the Babcock?
2. What are the causes of variation in the percentage of butterfat in milk?
3. Give a list of the equipment necessary for the farmer who tests milk.
4. What precautions are to be taken in keeping the acid for the test?
5. How would you take samples for testing for individual cows?
6. Describe the process of filling the pipette and transferring the milk to the test bottle.
7. How is acid added to and mixed with the milk?
8. Describe the centrifuging of the bottle—detailing various precautions to be followed.
9. How does testing cream differ from testing milk?
10. How is Babcock glassware washed?
11. Define specific gravity.
12. Describe the following: The pipette; the milk-test bottle.
13. Describe the appearance of a complete test and some possible variations and what they indicate.
14. Work out the problem of Spot, Fawn and Dot, as outlined under 1, 2 and 3, Table 1.
15. Work out the problems under Tables 2 and 3.